Accelerators Report

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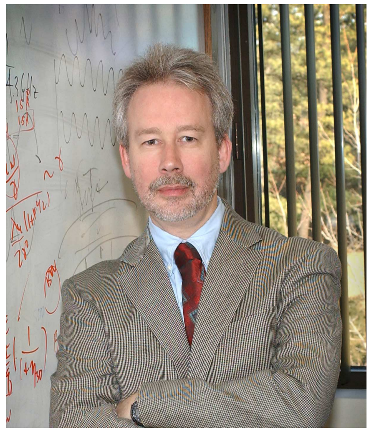
Organization and Mission



The NSLS Accelerator Division (AD) was established in late 2001 through reorganization of the NSLS and is headed by James B. Murphy. The division is organized into two sections: the Linear Accelerator (Linac) Section, headed by Xijie Wang, and the Storage Ring & Insertion Device Section, headed by Boris Podobedov. The staff consists of eight accelerator physicists, two engineers, three technicians and three postdocs.

The NSLS Accelerator Division (AD) has a four-part mission:

- To ensure the quality of the electron beam in the existing NSLS linear accelerator and storage rings: the x-ray and vacuum ultraviolet rings;
- To operate the NSLS Magnet Measurement Labo ratory;
- To participate in the NSLS upgrade;
- To perform fundamental research and develop ment in accelerator and free electron laser phys ics, e.g., the deep ultraviolet free electron laser (DUV-FEL) experiment.

2002 Activities

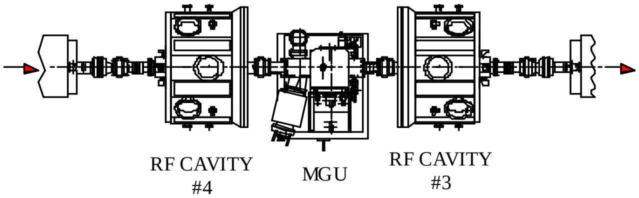
The AD staff maintains and improves the electron beam quality in the NSLS accelerator complex through research and development and weekly machine studies programs. More than a decade ago, the NSLS developed the first global orbit feedback system for a storage ring light source. This early system was based on analog components. In the intervening years, digital technology has exploded and it became clear that continued improvements in the global feedback system could only be realized by making the transition to digital technology. The AD staff, working in close collaboration with the Operations and Engineering Division staff, has developed and implemented digital orbit feedback systems on both storage rings. Key advantages of the digital feedback systems include: a) scalability to a larger number of beam position monitors and correctors; b) more sophisticated correction algorithms; c) potential for machine diagnostics; d) ease of maintenance due to compact system size.

Accelerator Division and Operations & Engineering Division staff designed and built an economical and yet effective digital system using the original architecture based on commercially available virtual machine environment (VME) boards. The system includes all the beam position monitors and most of the correctors, and is running at a sample/update rate of five kilohertz, leading to correction bandwidths in excess of 100 hertz and limited only by the bandwidth of the correctors.

The VUV ring digital global orbit feedback was used in regular operations for over two years. A 60-hertz digital notch filter, which eliminates the power line noise on the vertical orbit, was recently added to the ring, demonstrating the flexibility afforded by the digital design.

The x-ray ring system was recently enhanced to perform both the global and local corrections at some of the beamlines. In particular, the gain-bandwidth product or the residual orbit noise of the system correcting the vertical orbit motion, which was put into operation in September 2002, performed significantly better than the old analog systems. This system has also proved to be very effective in pinpointing the sources of orbit disturbance. Work is ongoing to make the x-ray ring horizontal system operational in fiscal year 2003.

In 2002, the Magnetic Measurement Lab efforts centered on assembling, measuring and shimming the magnetic arrays for the next mini-gap undulator, called MGU-29. The magnet arrays are now ready to be mounted in their support structure and vacuum vessel, which are also nearing completion. MGU-29 will be installed in May 2003 between the two radio-frequency accelerating cavities in the X29 straight section of the x-ray ring, to serve a new protein crystallography beamline funded by the National Institutes of Health.



2nd in-vacuum Mini-Gap Undulator will be installed between pair of RF cavities in X29 straight section to serve a new NIH-funded PX beamline

Other ongoing projects include:

- Design study of a novel, variable polarization undulator with quasi-periodic magnet arrays, to replace the X1 soft x-ray undulator
- Design study of superconducting, short-period undulators to generate tunable hard x-rays in the 2-20 keV range in the present x-ray ring, as well as for the proposed NSLS Upgrade
- Participation with the Stanford Linear Accelerator Center in Menlo Park, California, the Advanced Light Source in Berkeley, California, and the Ad vanced Photon Source in Argonne, Illinois, in a collaborative proposal to the Department of Energy (DOE) for research and development on a superconducting undulator
- Magnetic design for a proposed permanent-mag net, in-vacuum, hard x-ray undulator to replace the X25 wiggler

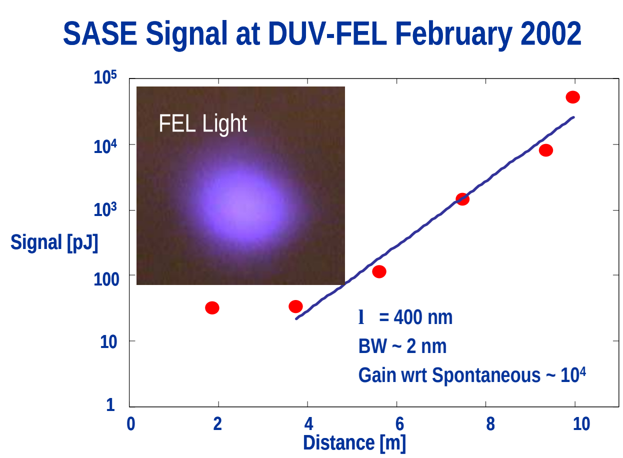
A primary emphasis of the AD in 2002 was to explore options for future light sources for the NSLS. The existing NSLS storage rings were designed more than a quarter of century ago. Although they continue to operate with exceptional reliability and high flux, they have been eclipsed by third-generation light sources. To maintain the NSLS at the cutting edge will require development of new light sources at the NSLS; high brightness storage rings, energy recovery linacs, and free electron lasers were all considered as part of this investigation. The NSLS is collaborating with its user community to refine the requirements of any new source and is working with DOE to ensure that the NSLS is in line with DOE's long-term plans for their facilities.

The scientists, engineers, and technicians working on the DUV-FEL experiment are developing advanced free electron laser sources and their scientific applications for the NSLS user community. The DUV-FEL laboratory consists of a radiofrequency photoinjector driven by a solid-state titanium sapphire laser system which provides an electron beam that is sent inside a linear accelerator, where the electrons' energy is increased to 200 MeV. To generate the high peak current required for the FEL, a four-magnet chicane bunch compressor is installed at the midpoint of the linear accelerator. To generate the FEL radiation, the electron beam traverses a 10-meter long NISUS undulator (Near Infrared Scalable Undulator System).

In 2002, tremendous progress has been made at the DUV-FEL. In February, the FEL generated spontaneous self-amplified emission (SASE) at 400 nanometers with a gain of 10^5. SASE at 266 nanometers with a gain length of 65 centimeters was subsequently measured in August, followed, in September, by the first achievement of saturation of an FEL seeded with 266-nanometer light from the titanium sapphire laser.

In the third quarter of 2002, the staff working at the DUV-FEL installed an evacuated laser transport line and matching optics for a High Gain Harmonic Generation (HGHG) FEL. After completion of the HGHG hardware installation in October 2002, HGHG saturation at 266 nanometers was obtained using 800-nanometer laser seeding, and measurements were performed to both characterize the HGHG output radiation and benchmark the performance against theory. An important benefit of achieving saturation in the HGHG FEL is that radiation at the third harmonic (89 nanometers) was also generated with an intensity of about one percent of the intensity at 266 nanometers.

Users of the FEL light performed the first chemistry experiment in December 2002 by using the 89-nanometer light to perform ion pair imaging spectroscopy. Two other BNL chemists have submitted proposals to explore the potential of the DUV-FEL radiation. The high intensity VUV light provided by the DUV FEL is complementary to the VUV ring sources and opens new horizons for the NSLS user community.



Gain length L_G=0.9 m